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This report reviews computing and network equipment purchased through a DUMP grant and their usage for supporting a currently funded DOD/AFOSR project. The research goal of the project is to develop the bottom-up self synchronization of QoS (quality of service)-centric stateful resource management, according to Complexity Theory for Complex Adaptive Systems, for a dependable information infrastructure that will be used to host network-centric information operations for the JRJ, NCW and JO towards Joint Vision 2010. To support this research, we needed to build a testbed for managing information infrastructure to: I) run large simulations of models developed for QoS management and analysis of emergent network behavior, 2) run large simulations of network activity under a variety of security threats to test the viability and efficiency of protocols being developed in this research project, and 3) run actual tests of network routing and QoS management while a large number of host machines generate substantial network traffic of varying profiles.

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Equipment for Research on Dependable Information Infrastructure

GRANT NO.:	**F49620-02-1-0271**
PI:	**Nong Ye**
Co-PIs:	**Ying-Cheng Lai and Partha Dasgupta**
SPONSOR:	**Air Force Office of Scientific Research**
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Abstract

This report reviews computing and network equipment purchased through a DURIP grant and their usage for supporting a currently funded DOD/AFOSR project. The research goal of the project is to develop the bottom-up self-synchronization of QoS (quality of service)-centric stateful resource management, according to Complexity Theory for Complex Adaptive Systems, for a dependable information infrastructure that will be used to host network-centric information operations for the JBI, NCW and IO towards Joint Vision 2010. To support this research, we needed to build a testbed for managing information infrastructure to: 1) run large simulations of models developed for QoS management and analysis of emergent network behavior, 2) run large simulations of network activity under a variety of security threats to test the viability and efficiency of protocols being developed in this research project, and 3) run actual tests of network routing and QoS management while a large number of host machines generate substantial network traffic of varying profiles.

List of Figure Captions

List of Table Captions

1. Objective of Equipment Grant

This DURIP grant has allowed us to purchase computing and network equipment to support a currently funded DOD/AFOSR project. The research goal of the project is to develop the bottom-up self-synchronization of QoS (quality of service)-centric stateful resource management, according to Complexity Theory for Complex Adaptive Systems, for a dependable information infrastructure that will be used to host network-centric information operations for the JBI, NCW and IO towards Joint Vision 2010. This futuristic dependable information infrastructure will overcome the problems with existing information infrastructures, e.g., the top-down centralized resource management with Computational Grids and the stateless resource management with Internet. Specifically, the objectives of the research are to investigate, implement and test two enabling elements of the dependable information infrastructure: 1) control strategies enabling bottom-up self-synchronization of QoS-centric stateful resource management; and 2) control and communication protocols to embed control strategies of self-synchronization into existing network protocols, such as TCP/IP to upgrade existing information infrastructures (i.e. the Internet) into dependable information infrastructures at affordable costs.

To support this research, we needed to build a testbed for managing information infrastructure to: 1) run large simulations of models developed for QoS management and analysis of emergent network behavior, 2) run large simulations of network activity under a variety of security threats to test the viability and efficiency of protocols being developed in this research project, and 3) run actual tests of network routing and QoS

management while a large number of host machines generate substantial network traffic of varying profiles.

The requested equipment is used to set up three networking domains (or Autonomous Systems (ASs)) in three laboratories at ASU. The three laboratories are Information and Systems Assurance Laboratory, Distributed Operating Systems Laboratory, and Applied Chaos Laboratory. Each of these laboratories will have a set of host machines (PCs) connected to 2 access routers. Each access router will connect to a core router and the core router connects to a border router. The border routers will be connected over the ASU network with the border routers of the other two laboratories. The access routers perform the authentication and flow control algorithms to be developed in the research. The core router manages the networking infrastructure of each Autonomous System. The border routers implement an enhanced version of the Border Gateway Protocol (BGP) that will allow us to control the traffic and authentication needs of the attack resilient hardened network (Figure 1).

The host machines will serve dual purposes. Sometimes they will be used in the modeling and simulation activities of the research and sometimes they will be used for simulation and testing of routing protocols. While the special purpose routers are to be used to implement the final prototype hardened network infrastructure, the development of the algorithms and the testing is often better done on general-purpose machines. These machines can be equipped with multiple network cards (NIC's) and is more suitable for developmental activities. Figure 1 shows the overall architecture of the testbed information infrastructure using the requested equipment.

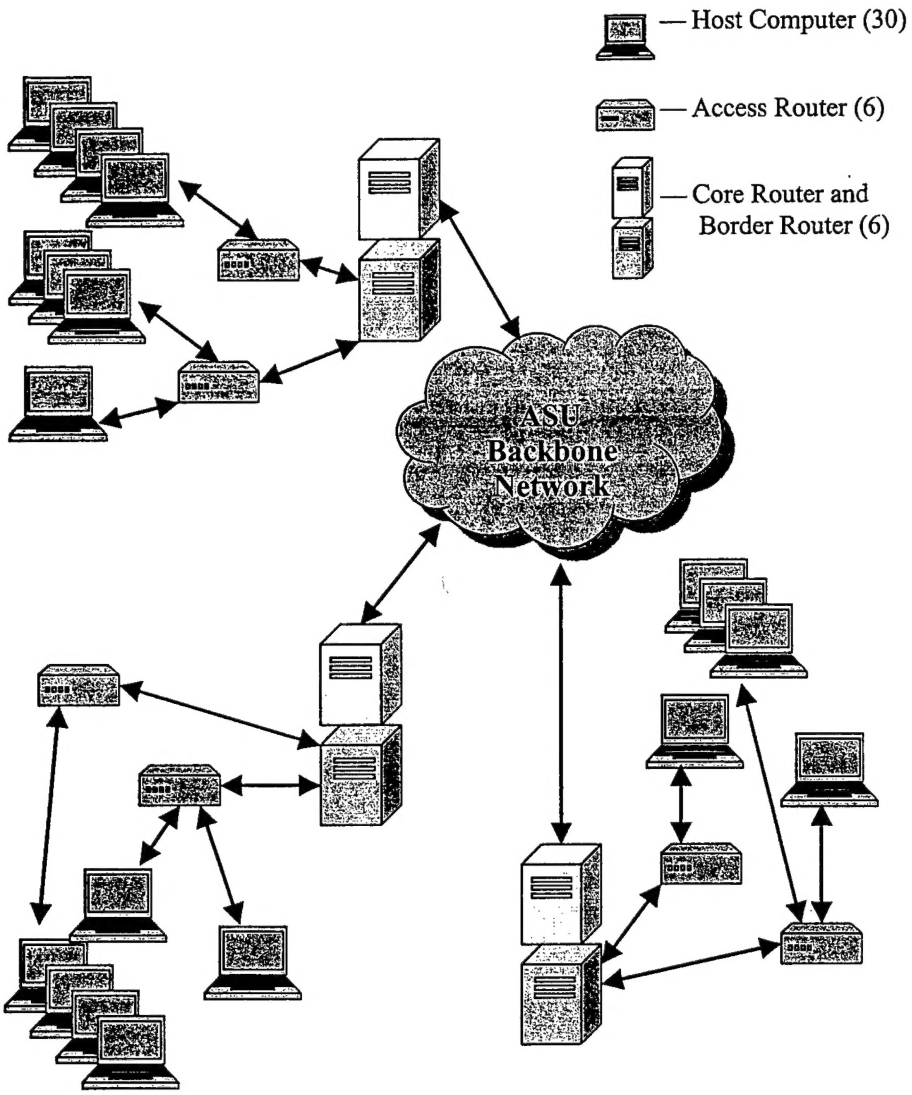

Figure 1-1. The architecture of a testbed information infrastructure.

The operating systems used will be of three types. The majority of the machines will be running either Windows (2000 or XP) or Linux. The Windows machines would be mainly for the client software and simulations, while the Linus machines will be used for routing, security prototyping and simulations. The third operating system would be Solaris, which will be used on some Sun machines that are being procured under the DOD/AFOSR URI CIP research grant (see supporting information)

The testbed information infrastructure constructed using the equipment supports the following research:

Sponsor:	DOD/AFOSR
Grant No.:	F49620-01-1-0317
PI:	Nong Ye, Arizona State University
Project Period:	May 1, 2001 – April 30, 2006
Funding Level:	$2,133,095
Project Title:	A Complex Adaptive System Approach to QoS Assurance and Stateful Resource Management for Dependable Information Infrastructure
Collaborator:	Air Force Research Laboratory

2. Equipment Purchasing

The equipment purchased with this funding was handled by the Principal Investigator (PI) and the two co-PIs. Each PI maintains a lab in which research is conducted. For each purchase, the equipment resides in the lab of the purchasing PI. Each of these research labs are on the Arizona State University main campus in Tempe, Arizona. The equipment purchases, totaling $113,993, are separated here by PI.

2-1 Equipment in Ye's Lab

The research has significant needs for computer and network equipment that is not currently available. We have computer and network equipment in our laboratory, but these are either committed to other research activities, or are getting outdated. We need to

replace the outdated equipment to ensure the level of support needed by this research project. The equipment in Table 2-1 is purchased to meet these needs.

Table 2-1: Ye's equipment purchases.

Date	Vendor	Description	Quantity	Cost
3/6/03	Dell	Standard Laptop	1	$2,307
		Laptop w/ wireless networking equipment	1	$2,820
		High-end dual processor workstation	1	$7,974
		Laptop and networking equipment and accessories	1	$942
9/19/02	Dell	2.6 GHz Xeon workstations w/ 4 GB memory	2	14,526
		2.0 GHz M50 Mobile workstation	1	$4,024
3/5/03	Arrow	ENP2505 Intel Network Processors (Programmable network routers)	3	$6,981
3/6/03	PSSC	Dual Xeon PowerWulf computing cluster w/ head node and 4 slave nodes	1	$12,984
3/19/03	Dell	PowerVault 1.7GHz, 480 GB, RAID network storage device	1	$2,724
4/14/03	Dell	Standard desktop	1	$1,171
			Total	**$56,453**

2-2 Equipment in Lai's Lab

Research equipment is needed to conduct simulated experiments. The equipment purchased to support Dr. Lai's research is described in Table 2-2.

Table 2-2: Lai's equipment purchases.

Date	Vendor	Description	Quantity	Cost
6/21/02	USSI	Intel Dual Xeon 2.4 GHz Server (2GB Memory, 146 GB Hard Drive)	1	$8,099
6/21/02	USSI	Intel P4 2.53GHz workstation (1GB Memory, 160 GB Hard Drive)	1	$3,599
7/19/02	SONY	Vaio R505 Laptop PC	1	$2,606
8/29/02	USSI	Intel P4 2.8GHz workstation (1GB Memory, 60GB Hard Drive)	1	$4,598
12/6/02	Microcenter	17" LCD monitor	1	$496
3/4/03	USSI	Intel P4 3.06GHz Server (1GB Memory, 200GB Hard Drive) AND Intel P4 3.06GHz workstation (1GB Memory, 120GB Hard Drive)	1	$9,650
			Total	**$29,048**

2-3 Equipment in Dasgupta's Lab

Our research had a need for computer and network equipment that was not available to us. The DURIP funds were used to provide the computers, and networking support was provided from the CIP grant and other grants. The equipment is described in Table 2-3.

Table 2-3: Dasgupta's equipment purchases.

Date	Vendor	Description	Quantity	Cost
12/16/02	USSI	Desktop Computers: Various Intel processors.	15	$20,940
2/10/03	USSI	Sony Vaio laptop PC	1	$2,032
4/14/03	USSI	Sony Vaio laptop PC	2	$5,520
			Total	**$28,492**

3. Equipment Use in Support of Research

Use of the equipment outlined in Section 2 is detailed in this section.

3-1 Equipment Use in Ye's Lab

The equipment purchased for this lab is used by graduate students and research associates in the lab to conduct research on the currently funded project. All of the computers are networked together using the wireless and wired networking equipment. As simulations of normal and attack scenarios are run on some computers, other computers are kept open to the Internet to collect network traffic data. The data collected is stored on the PowerVault data storage device. Some computers are also used to run the simulation model of the Internet to collect data from which to discover locations and measures of data for detecting global emergent system states of the information infrastructure.

Programmable routers are used to test various QoS methods across a router, at the global level. The high-end and wireless laptop computers are used in simulations at the global level. Some workstations are used as host machines and servers for testing QoS methods at the local and regional levels respectively. Host data is collected from all of the computers for analyzing performance under various conditions. The computer set runs both Windows and Unix based operating systems to ensure a variety of data.

In addition, presentation based equipment, such as printers and cables, are used to aid in the dissemination of research. Other miscellaneous equipment includes that which is necessary to build and maintain a large local network of computers.

3-2 Equipment Use in Lai's Lab

As requested in the proposal, almost all pieces of equipment are Intel Pentium workstations and accessories (except Item #3) above. The computers are necessary for the PIs, the post-doctoral fellow, and students to perform scientific computation, data analysis, and visualization pertinent to research in the CIP project. The SONY laptop PC (Item #3) is for scientific computing and presentation.

3-3 Equipment Use in Dasgupta's Lab

The desktop computers were used for running large simulations of network activity under a variety of security threats to test the viability and efficiency of protocols being developed under the project. In addition the computers were used to run prototypes of hardened networks using both Linux routing as well as routing using Network Processors. These computers were instrumental in developing a wide variety of results in terms of network performance under varying security requirements

The laptop computers served mainly as development platforms for the simulations and prototypes. They were also used to perform experiments on wireless security vulnerabilities and to develop solutions for countering attacks on 802.11b networks. Additionally they have been useful for providing support for demos and presentations.

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